lection contained this species as well as Mr. Treacher's; but it was already recorded from the locality by Motley and Dillwyn.

136. Sterna melanauchen, Temm.

Sterna melanauchen, Saunders, P. Z. S. 1876, p. 661.

Common in April, May, and June, according to Governor Ussher.

137. Anous melanogenys, Gray.

Anous melanogenys, Sharpe, Report Trans. Venus Exped., Birds of Rodriguez, p. 10.

One adult specimen sent by Mr. Treacher. Native name "Tara tara." I have shown the specimen to Mr. Howard Saunders; and he confirms the identification.

3. On the Conformation of the Thoracic Extremity of the Trachea in the Class Aves.—Part I. The Gallinæ. By A. H. Garrod, M.A., F.R.S., Prosector to the Society.

[Received October 31, 1878.]

Inspection of the windpipes of several species of allied birds makes it evident that the bifurcation of that tube to form the bronchi is brought about in different ways in almost every case, by various alterations of greater or less degree in the proportionate development of the several rings and semirings entering into the composition of the organ. In the case of the non-oscinine Passeres, Johannes Müller has proved the great importance of the study of the "lower larynx" or syrinx in the determination of the affinities of the species. In the present communication it is my desire to continue his line of investigation to other families of the class, laying more stress on the cartilaginous structures, and less on the muscles moving them. Opportunities are specially in favour of my studying the Gallinæ at the present time; therefore this first fasciculus is an account of the bifurcating windpipe in those species of the Order which it has been my good fortune to examine.

By C. J. Temminck, in his valuable 'Histoire Naturelle Générale des Pigeons et des Gallinacés'[1], several of the windpipes of the Gallinæ are figured. These will be mentioned when the respective species are discussed.

It is in the Peafowl that the thoracic termination of the trachea is less complicated, as far as my experience goes, than in any other Gallinaceous bird; and the arrangement is so simple that it is not easy to imagine one much more so[2].

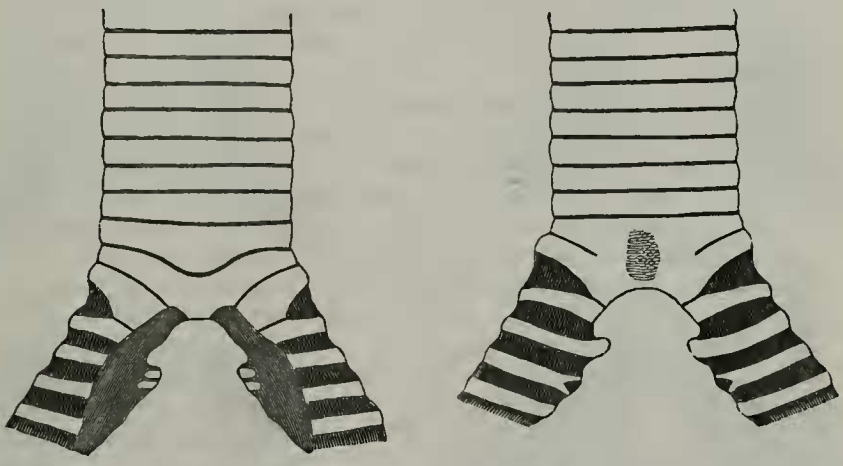
In the chick (a month old) of *Pavo spicifer* (figs. 1, 2) the antepenultimate tracheal ring is free, and agrees with those above it in that the interannular intervals are reduced to a minimum, at the same time

[1] Amsterdam, 2 vols., 1813 and 1815.

[2] *Vide* Temminck, *loc. cit.* pl. i. fig. 2.

that anteriorly it is slightly bent downwards in the middle line, to assist in the changes of form connected with the bifurcation of the tube. The penultimate ring, from its position, is more pronounced in this respect, whilst posteriorly the pessulus runs up to blend with it, not at its inferior margin, but by a wedge-shaped cartilaginous expansion, the apex of which touches the lower margin of the ring above. That this is so is proved by the existence of two oblique indented lines, one on each side, converging superiorly, where they nearly meet to form the apex of the just-mentioned wedge. The last tracheal ring anteriorly sends down an obtuse median process, the inferior margin of which constitutes the summit of the notch

Fig. 1. Fig. 2.



Front view. Back view.

Pavo spicifer (adult).

N.B.—This and all the subsequent diagrams are drawn to one scale, and have no relation to the actual size of the structures.

between the divaricating bronchi, whilst its posterior surface forms the anterior attachment of the pessulus. Posteriorly this ring is incomplete, the two obliquely truncated ends being separated by a considerable interval occupied by the pessulus in the middle line, and laterally by the commencement of the membranous inner walls of the bronchi.

In the middle of the upper border of the penultimate ring anteriorly a white line is seen sending a limb down on either side, beyond the ring itself, onto the next, at the lower margin of which it ceases at the root of the obtuse median process. Such an appearance indicates that in the older bird fusion of the two rings will occur at the spot, as an inspection of the part in the adult verifies. From the above description it will be also seen that the pessulus—a slender cylindroid bar, expanded and flattened at each end—is anteriorly attached to the last, and posteriorly to the penultimate

ring of the trachea. The last tracheal ring, it must not be forgotten, is incomplete behind.

The first bronchial semiring—for in no Gallinaceous birds are any of the bronchial rings complete—articulates at both its extremities with the last tracheal, anteriorly along the side of the oblique median process, posteriorly with the lower angle of its square-cut termination. Both ends are slightly expanded and obliquely truncated, their acute upper angles being their articulating spots. The lower margin of the last tracheal ring being concave downwards and slightly uptipped laterally, whilst the first bronchial semiring descends slightly from its attachments outwards, a considerable membranous interannular interval is left. The second bronchial semiring is simple, free, and slightly expanded posteriorly. In front the third was bifurcated in both bronchi, on one side each branch being further subdivided. The depth of the bronchial interannular membranes is about the same as that of the semirings themselves.

Between the membranous inner wall of one bronchial tube and the same part of the other there is a dense fibrous band of union, a short distance below the bifurcation of the windpipe, and generally on the level of the two or three semirings below the second. This band is, I believe, always to be found in birds (it will be termed the *bronchidesmus* in this communication) developed to a greater or less extent. Being of fibrous tissue and connected with the membranes of the neighbourhood, anatomists have removed it whilst dissecting the organ for examination. Its importance, however, is more considerable than might be at first imagined; and I only regret that in many of the subjoined descriptions I took no note of it. In birds like the Tetraonidæ the bronchidesmus is so strong that it cannot escape special observation.

The adult female presents no modifications of importance. The penultimate and last tracheal rings are relatively a little smaller and have blended in front in the middle line, whilst all trace is lost of the shape of the posterior termination of the pessulus. The articulating surfaces of the first bronchial semiring have become slightly more considerable.

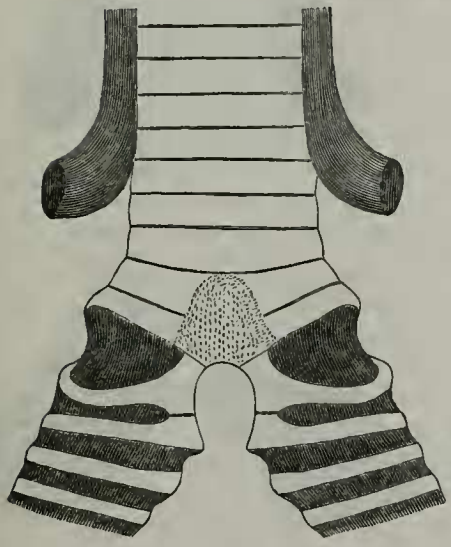
The adult (male) *P. nigripennis* differs in that the antepenultimate tracheal ring blends anteriorly with the penultimate, at the same time that there is a greater fusion between the penultimate and last rings, all three apparently blending behind as well. The interannular interval between the last tracheal ring and the first bronchial semiring is reduced to little more than a line, and the bronchial interannular intervals are very small.

It is to be specially noted that in the genus *Pavo* the second bronchial semiring, by not articulating with the one above it at either end, does not participate in the formation of the specialized lower larynx. This is a feature indicating non-elaboration of the organ. No other Gallinaceous bird with which I am acquainted resembles *Pavo* in this respect.

In *Caccabis rufa* the thoracic extremity of the trachea is perfectly

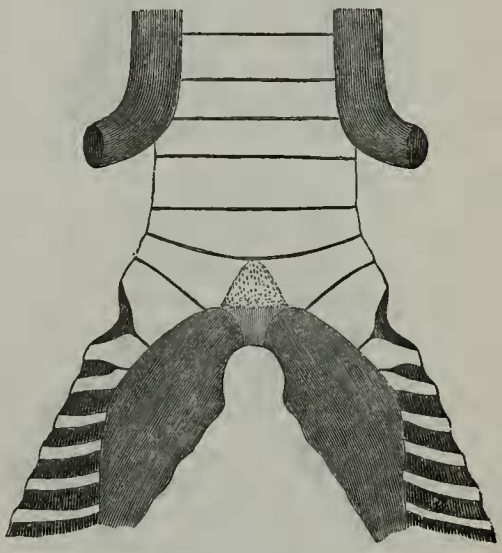
simple, and all the rings are in contact with those contiguous to them throughout their circumference. The lower margin of the penultimate ring faces slightly outwards on either side, whilst in the middle line in front it fuses with the ring below it, a well-defined semiellipsoid ossification developing in the region, upwards as far as the upper margin of the penultimate ring, and downwards to the mediau point of bifurcation of the last ring, from which it extends laterally a short distance. The pessulus is attached as in *Pavo*. It is ossified, the anterior termination being the ossification just described; the posterior is a triangular extension into the middle of the posterior surface of the penultimate ring, the apex of which reaches its superior margin. The first bronchial semiring is con-

Fig. 3.



Front view.

Fig. 4.



Back view.

Caccabis chukar.

cave upwards, and in front forms a sharp inturned angular process at the spot where it articulates with the anterior extremity of the second semiring. Posteriorly its articular upward-directed process is more developed—so much so that the contour line of the posterior extremity of the last tracheal is continuous with that of the ring under consideration and the next as well. The second bronchial semiring differs but little from those which follow it, except in that it articulates with the one above. Its extremities are somewhat more expanded, and articulate freely with the angles of the first ring. Anteriorly it sends inwards a pointed angular process, which advances further towards the middle line than does the similar angle of the semiring above, with which it closely articulates. The semirings which follow have

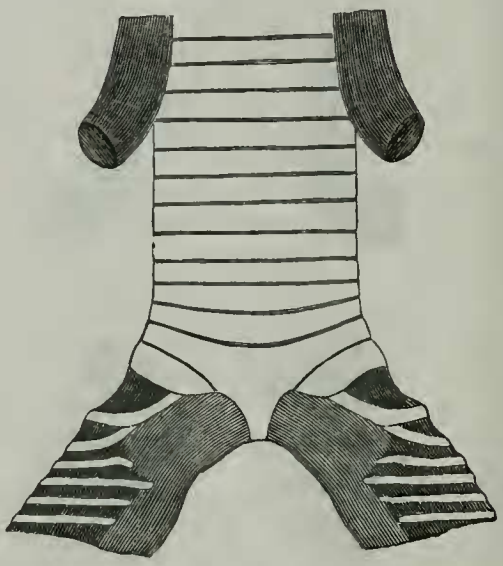
also pointed anterior ends, running inwards almost as much as does the second, in a manner very characteristic of all the genera in which the second semiring is pointed and prolonged. There is no trace of any interval between the penultimate and last tracheal rings. Between the last and the first bronchial semiring the interval is a capacious ovoid. That between the first and second bronchial semirings is elongate and shallow, not deeper than the lower bronchial intervals. *Caccabis saxatilis* agrees with *C. rufa*, except that in the former there is a slight development of antero-lateral interannular intervals between the lower tracheal rings, as in *Argus*, the account of which follows.

In *Argus giganteus* the lowermost tracheal rings are separated by

Fig. 5.

Front view.

Fig. 6.



Back view.

Argus giganteus.

narrow intervals in front, where in the middle line the last three fuse and ossify into a mass whose lower border descends but little below the level of the inferior margin of the unmodified last ring for the articulation of the anterior extremities of the first bronchial semirings. Posteriorly the pessulus joins the penultimate ring, the two hinder ends of the last ring being well separated. The first bronchial semiring is large and strongly convex downwards from the development at each of its ends of upturned articulating processes, at the junction of which with the horizontal portion of the tube the second semiring articulates along its lower border. The interval between each lateral element of the last tracheal ring and its corresponding first bronchial semiring is considerable, tending to a quadrate form, whilst that between the first and second semi-

ring is much narrower and meniscoid. The second semiring itself is strongly convex downwards, articulating behind by its extreme end with the ring above, but in front continuing onwards as a triangle beyond the articular point into the internal bronchial membrane a short distance. The anterior terminations of the few lower bronchial semirings are similarly pointed; and posteriorly they run inwards (especially the fourth and fifth) considerably more than do semirings one and two.

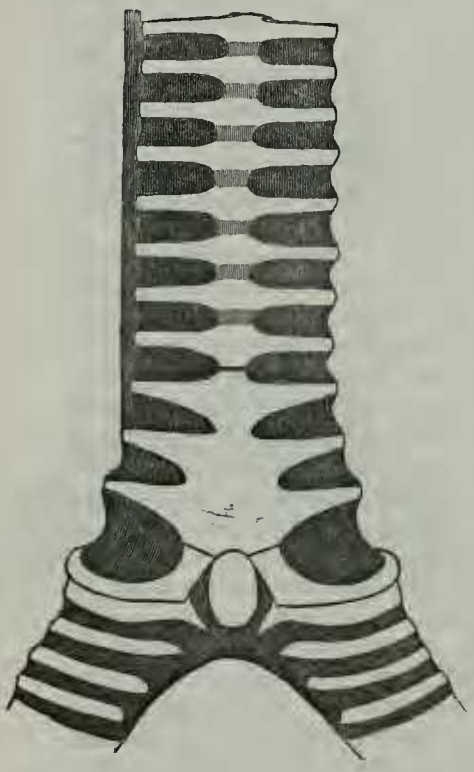
Polyplectron chinquis so closely resembles *Argus* in all respects that no description of it is needed. The first and second bronchial semirings are proportionately a little stronger; the antepenultimate tracheal ring does not actually fuse with the penultimate, and in one specimen the pessulus, instead of blending with the penultimate ring behind, runs upwards cuneately between the separated ends of that ring to touch the lower margin of the antepenultimate ring. From this and other facts pointing in the same direction, to be mentioned subsequently, it may, with much probability, be inferred that this arrangement just mentioned is the typical one, consolidation of the pessulus with the posterior extremities of the penultimate tracheal ring having occurred in those cases where, among the Gallinæ, that bar is found connected with it.

In *Ithaginis geoffroii* (♂ adult) there is a transversely fusiform median interannular interval between the lower tracheal rings anteriorly, entirely absent behind. The antepenultimate and penultimate rings are slightly separated throughout, most at the sides, whilst between the penultimate and last rings—fusing though they do in the middle line anteriorly—there is a slight elongated oblong interval on either side of the fused isthmus, extending outwards as far as the lateral margin of the tube, but not further backwards. The pessulus gives no indication of separation from the penultimate tracheal ring posteriorly, whilst anteriorly it springs from the last ring, between which and the first bronchial semiring there is a considerable interval. This semiring is somewhat squared, sending up processes (an anterior and a posterior) of no great length to articulate with the last tracheal ring, the second semiring (scarcely differing from the third) just touching its two angles sufficiently for it to be said that it does articulate with it. In this species the lateral sterno-tracheal muscle terminates inferiorly in a peculiar manner. It is constituted of two parts, an outer and an inner. Of the inner, which is also divided below into two, the median portion ceases at the twelfth ring from the bifurcation, opposite which spot its outer moiety sends downwards a special thin extra broad fasciculus to join the undivided outer main element of the muscle just before it leaves the windpipe, opposite its antepenultimate ring. The nerve to these lower fibres is not small; and from being superficial—resting as it does on the muscles under consideration as they descend—it disappears behind the special fasciculus above described at the spot where that begins to run inwards towards its fellow, which it does not meet.

In *Lophortyx californicus* (adult male) there are no interannular

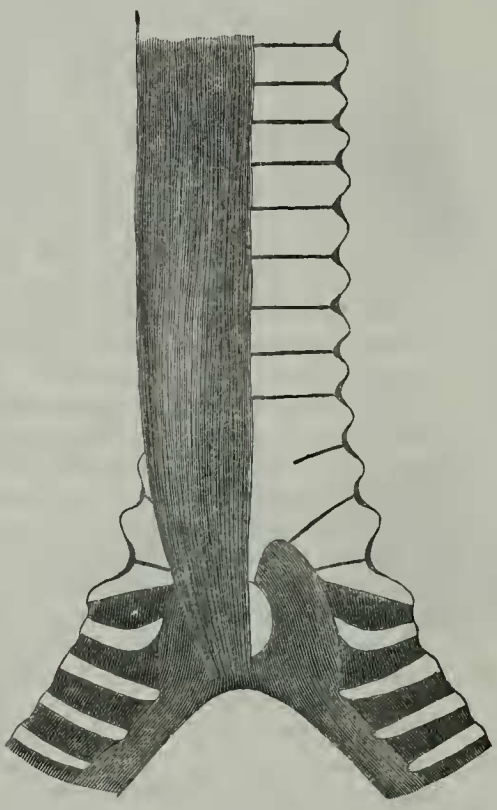
intervals on the posterior aspect of the intrathoracic portion of the windpipe [as in so many of the birds under consideration, and dependent, no doubt, upon the proximity of the œsophagus]; but anteriorly the lowermost twelve rings are thinned in such a way that the intervals are uniform and deeper than the rings forming them, at the same time that their breadth is half the circumference of the tube itself, they continuing across the middle line, except in the case of the lowermost three, which are divided up by median junc-

Fig. 7.



Front view.

Fig. 8.



Back view.

Lophortyx californicus.

tions of the rings, narrow and not fused between the antepenultimate and the one above it, broad and blended in the two below it. There is a narrow medio-anterior vertical fibrous bond between all the upper thinned rings, taking the place of the lower cartilaginous isthmuses. Posteriorly the penultimate and antepenultimate rings blend in the middle line, the pessulus joining the former in the usual manner. The last ring is typical and incomplete behind. The first bronchial semiring is large and concave upwards.

It develops a considerable angle on its convex border in front, at the spot where the next semiring meets it. Behind it is peculiar from its inconsiderable thickness, it meeting the corresponding extremity of the last tracheal ring for some distance, opposite which part it is so narrow that the expanded hinder end of the second semiring does not manage to reach it, and remains separated by a small interval. This second semiring meets it in front, and sends inwards beyond the articulating spot a pointed process of some length. The lower bronchial rings are similarly pointed and prolonged in front.

The bronchidesmus is powerful, at the same time that its posterior margin is the place of insertion of the pair of contiguous powerful muscles that runs down the back of the windpipe, and spreads laterally so much as to be just seen in the anterior view of the organ.

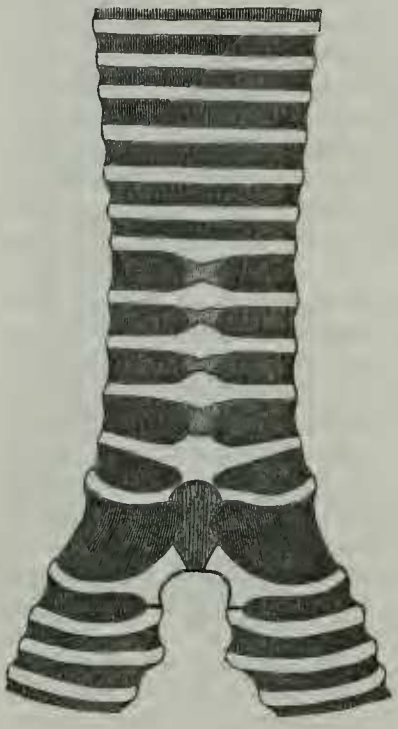
The windpipe of *Oreortyx pictus* differs in detail from that of the bird just described. The penultimate and last rings of the trachea blend in the mid-anterior and posterior line; whilst behind the antepenultimate does so also, articulating in front. The next four rings anteriorly are lozenge-shaped in the middle line, the six above which are uniformly thinned; but the intervals between them are much less considerable than in *Lophortyx californicus*. Posteriorly there are no interannular intervals at all. The bronchial semirings, the posterior muscles, and the bronchidesmus are as in *Lophortyx*.

In *Arboricola atrogularis* the bifurcating portion of the windpipe most closely resembles that of the American Quails. With no posterior interannular intervals, those in front are deep and twelve or so in number, being interrupted, in the case of that between the last and penultimate rings, by a large medio-anterior lozenge-shaped ossification which unites them, but continuous above except that a fine fibrous band runs up the tube, as in *Lophortyx*, previously described. The thinned antero-lateral element of the last ring has a slight special downward curve towards its inner end. In *Oreortyx* there is an indication of the same. The second bronchial semiring is prolonged inwards pointedly in front, and posteriorly *does* meet the first semiring to articulate slightly with it.

In *Coturnix communis*, with which *C. coromandelica* agrees in every respect, the posterior surface of the intrathoracic portion of the trachea is seen to be formed by rings between which no interannular intervals exist, except as transverse lines. Anteriorly, however, the rings are very much thinner, becoming so abruptly at the side of the tube, and the intervals between them are nearly twice their depth, even more than that towards the bifurcation of the tube. Narrow medio-anterior perpendicular isthmuses of fibrous tissue connect the lowermost six rings. Laterally the penultimate ring is slightly upturned, more behind than in front. The antero-lateral thin portion of the circumference of the last ring is decidedly convex downwards, as is also the first bronchial semiring and the second. The last tracheal ring sends downwards a medio-anterior oblong process, ossified in the adult, to the lower angles of which

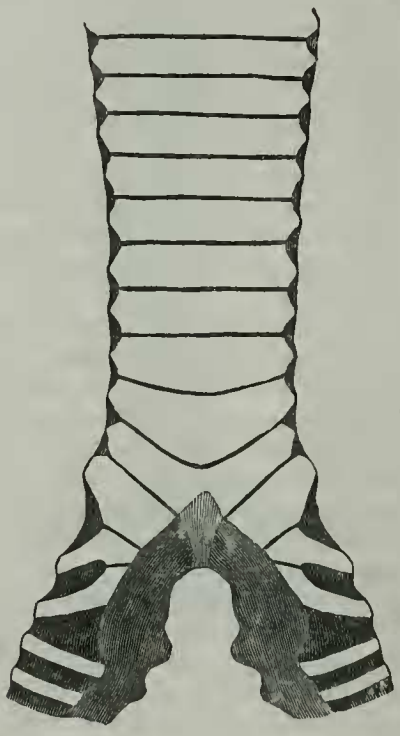
the first semirings articulate by their equally lengthy extensions inwards beyond the short articular processes for the second semirings. The posterior articulations of the incomplete last tracheal ring with the first semiring, and of that with the second on each side, are considerable, and much the same in detail as in *Caccabis*. The pessulus blends with the penultimate ring behind. The lateral intervals between the penultimate and last rings are plano-convex, the plane side being uppermost; those between the last ring and the first bronchial semirings are meniscoid, very deep, and concave upwards. Between the first and second semiring the interval is small, elongate, and curved like the one above it.

Fig. 9.



Front view.

Fig. 10.



Back view.

Coturnix communis.

Ptilopachys ventralis differs very little from *Coturnix* in this part of its windpipe.

Rollulus coronatus closely resembles the Oxtyxes and Quails. There are five fairly deep antero-lateral interannular intervals between the lowermost six tracheal rings, these same rings meeting in the middle line in front as well as through all the posterior moiety of the circumference. Ossification extends through the median fused anterior portions of the penultimate and last tracheal rings, as well

as a short distance posteriorly into the middle of the lower border of the penultimate ring, from the fair-sized bony pessulus. The last tracheal ring sends downwards a thick short process from its hinder end on either side, to articulate with the equally developed upturned posterior extremity of the first bronchial semiring, the anterior upward- and inward-directed terminal limb of which is proportionately long, at the same time that the angle it makes with the main element of the ring is very abrupt. The second semiring is nearly in contact superiorly with the first throughout its length. Anteriorly it ends in a point, as do the lower semirings, which extends a short distance into the inner membranous wall of the bronchus. Posteriorly it is slightly enlarged and rounded, ceasing a short distance outside the posterior angle of the semiring above, with which it is in contact.

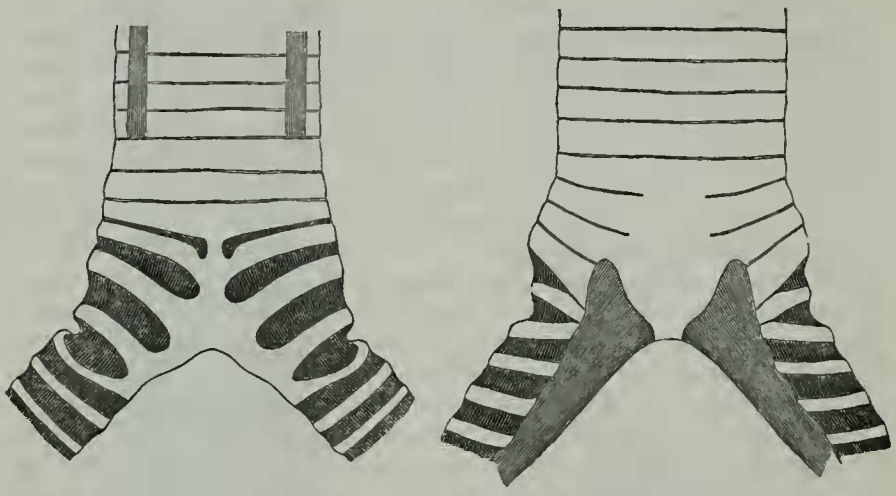
Turning to the genus *Euplocamus*, in *Euplocamus swinhoii* the last four tracheal rings become slightly enlarged from above downwards. Between the simple antepenultimate ring and the one above it there is a slight interval, except in the middle line behind, where a general fusion of the last three rings occurs, as in all *Euplocami*. The penultimate ring sends downwards a narrow tongue-shaped median process anteriorly, which touches, but does not join, the upper margin of the there indented terminal tracheal ring. Its upper margin is also slightly irregular. The last ring is peculiar in front. Besides the shallow and broad concavity in the middle of its upper border, it sends downwards a deep and transversely considerable semiovoid process, notched at its apex, which is lowermost, to form the median element of the actual bifurcation of the tube. On either side of this notch, just beyond it, the anterior extremity of the first bronchial semiring articulates by its triangularly expanded end, the lower angle of which is jointed with the not much specialized second semiring, which posteriorly articulates by its somewhat expanded termination with the first semiring also. The hinder extremity of the first semiring fuses with the last tracheal, as does the posterior termination of the pessulus, to form a continuous cartilage along the back of the tube as high as the upper border of the antepenultimate tracheal ring. Antero-laterally the annular interval between the penultimate and last rings is well developed, and bent downwards near the middle line on account of the presence of the process and notch above described. The interval between the last tracheal ring and the first bronchial semiring is very large and deep on account of the great size of the descending process of the former. The interval between the first and second semirings is ovate and slightly deeper than those which follow. The pessulus is narrow.

Euplocamus prælatus, *E. nychthemerus*, and *E. albocristatus* differ from *E. swinhoii* in that anteriorly the median process from the lower border of the penultimate ring blends with the upper border of the last tracheal, as does the upper border, but by a more slender isthmus, with the antepenultimate. In *E. nychthemerus* and *E. albocristatus* there is a further fusion of the anterior extremity of the

first semiring with the last tracheal at its (should be) articulating spot.

The pessulus is broad; and the angle on each side of its posterior blending with the penultimate ring runs a short way into the latter so as to reduce its depth a little at the spot. The interannular intervals are the same as in *E. swinhoii*, except the one between the antepenultimate and penultimate rings, which is interrupted in front by the narrow cartilaginous isthmus between them. Above this the following twelve rings or so touch all round; and they are succeeded by typically interlocking rings in the cervical portion of the tube. It must be also mentioned that whilst the plane of the penultimate tracheal ring is transverse, that of each lateral moiety of the

Fig. 11. Fig. 12.



Front view. Back view.

Euplocamus albocristatus.

last one, as well as the first bronchial semiring, runs upwards from its more fixed median anterior and posterior parts. The plane of the second semiring makes an angle of some 15° with the first.

In this last respect, as well as others, the genus *Phasianus* differs from *Euplocamus*. In *Phasianus wallichii*, *P. colchicus*, and *P. versicolor* the plane of each tracheal ring, as well as that of the uppermost bronchial semirings, is nearly, if not perfectly, transverse. The whole trachea narrows slightly at its lower end, to expand again opposite the last two or three rings. As in *Euplocamus*, the last three rings fuse in the middle line behind, as do the last two (in *P. wallichii* the last three) in front, whilst in adult birds the anterior extremities of the first and second semirings participate in the blending, as does the pessulus posteriorly. In *P. colchicus* and *P. versicolor* (which differ from *P. wallichii* about as much as *Euplocamus swinhoii* does from its allies) there is a robustness about the

last two tracheal rings and the first two bronchial semirings peculiar to them. Their direct front view always exhibits the posterior articulation of the first bronchial semiring with the ring above and the semiring below, as in no other Gallinaceous bird with which I am acquainted; thus, it includes the whole of the considerable interannular intervals between them, the upper ovoid, the lower semiovoid, with its convexity downwards. In *Phasianus* there is no interval between the penultimate and last tracheal rings, nor any of importance higher up. In *P. colchicus*, however, above the ante-

Fig. 13.

Front view.

Fig. 14.

Back view.

Phasianus colchicus.

penultimate ring, there are small median intervals, fusiform and elongate in front, minute behind. These shortly become the notches of the interlocking superior rings.

Pucrasia darwini is so like the genus *Phasianus*, as far as the parts under consideration are concerned, that it needs no separate description. Any difference is in the direction of *Euplocamus*, the sides of the last tracheal ring being slightly uptilted.

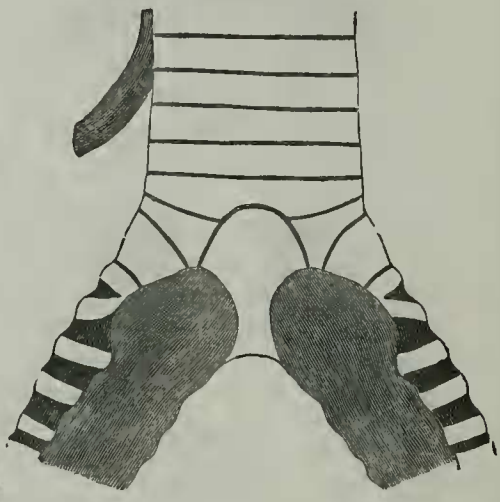
Returning to *Euplocamus*, a start in another direction brings us to *Thaumalea*, *T. picta* and *T. amherstiæ* being identical, as far as their windpipes are concerned. In this genus the intrathoracic rings (tracheal rings) are in contact all round, as far as and including the penultimate ring, which sends down a short median anterior process to articulate with a small corresponding upward-directed one from the upper margin of the last ring. Posteriorly, in the young bird, the blunted triangular extremity of the pessulus interpolates itself between the two slightly expanded ends of this (therefore imperfect) ring, its extremity meeting and even disrupting

the continuity of the lower edge of the antepenultimate ring to a small extent. The last tracheal ring is characterized by the great obliquity of the plane of each of its lateral moieties, the downturned angle between which is less than 45°. Behind there is a considerable interval between its downward-directed ends, filled up by the pessulus, which is prevented from touching them by the intrusion of the extremities of the similar parts of the, also incomplete, penultimate ring. In front the middle of the ring is expanded into a large, quadrilateral, square-set cartilage, ossified in the adult, from the superior angles of which the slender oblique side elements of the ring take origin, to the inferior angles of which the first bronchial semiring is articulated in the chick and consolidated in the adult;

Fig. 15.

Front view.

Fig. 16.



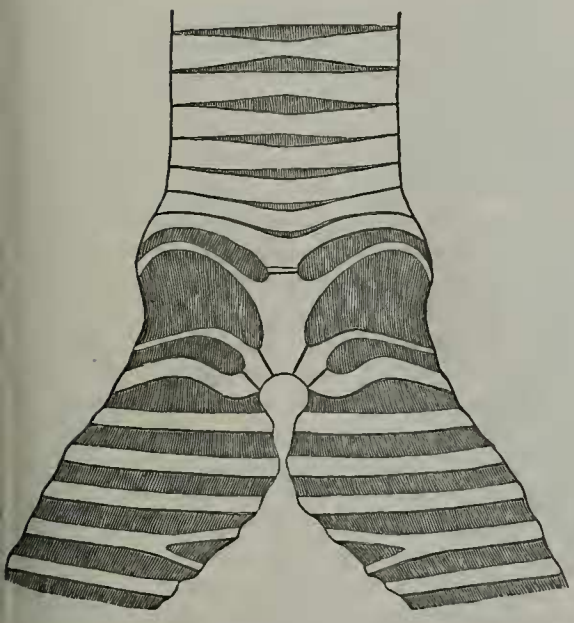
Back view.

Thaumalea picta.

the middle of the superior margin of which also articulates or blends with (according to the age) the broad median descending process of the penultimate ring. The first and second bronchial semirings are much alike; both are slightly swollen at their extremities, especially the anterior; and their planes of direction are parallel, which is not the case in *Euplocamus*. The lateral intervals between the penultimate and last tracheal rings are like the section of a plano-concave lens with the concavity (formed as it is by the arch of the lateral moiety of the last ring) downwards. The interval between the last ring and the first bronchial semiring is considerable and broadly fusiform; that between the first and second semiring is narrow and lanceolate, or fusiform in the adult, where the two semirings consolidate at their extremities.

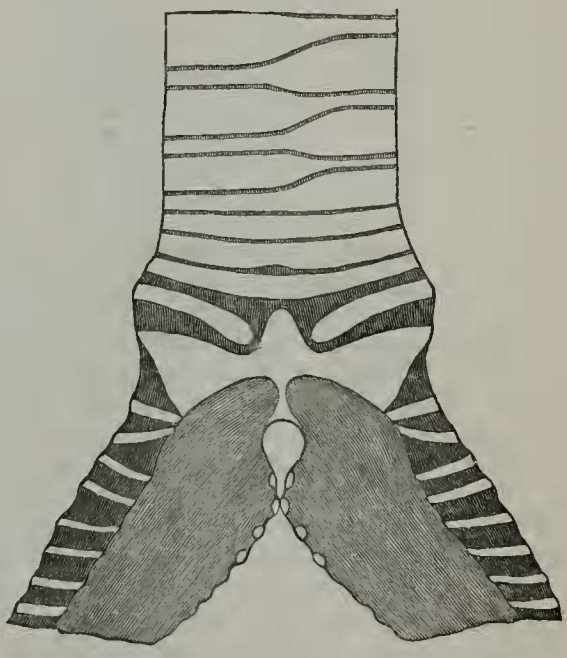
Lagopus scoticus is not far different from *Thaumalea* in certain respects. The lower intrathoracic rings of the trachea are but little modified above the antepenultimate, there being slight median fusiform anterior interannular intervals, whilst posteriorly the ununited rings are keyed together, as in the middle of the windpipe generally. The penultimate ring agrees with the same in *Thaumalea*, even to being incomplete behind, the free ends slightly receding from the ring above. The last ring anteriorly agrees with the same genus in detail, its lateral arched moieties being even more slender and delicate. Posteriorly, however, its ends develop into large fairly equilateral triangular expansions, continuous with the slender lateral arch at its supero-external angle, articulating with the posterior end of the first bronchial semiring at its inferior angle, whilst its supero-

Fig. 17.



Front view.

Fig. 18.



Back view.

Lagopus scoticus.

internal angle joins a similar development at the side of the pessulus, the hinder part of which expands into a sagittate cartilage, the blunted apex of which is directed upwards to meet the middle of the inferior margin of the antepenultimate ring of the trachea. The main bar of the pessulus is very slender; and all the structures under consideration are built up of a much more yielding cartilage (without ossifying tendencies) than in any non-tetraonine birds. The first and second bronchial semirings are parallel to one another in course throughout, and are more uptilted laterally than in *Thaumalea*. Pos-

teriorly they are not expanded and scarcely touch; anteriorly they expand a little and articulate freely. The interannular intervals in essential points are not different from the preceding genus. The bronchial semirings below the second are peculiarly lengthy; their extremities turn inwards toward one another, and so slightly intrude into the membranous inner wall of each bronchus. One or more of the semirings may be bifid at their anterior ends. The bronchidesmus is particularly powerful in the Tetraonidæ, including *Lagopus*, and, as it were, pulls the two tubes into nearer relationship than would otherwise appear to be their tendency.

Lagopus mutus agrees with *L. scoticus* in every respect.

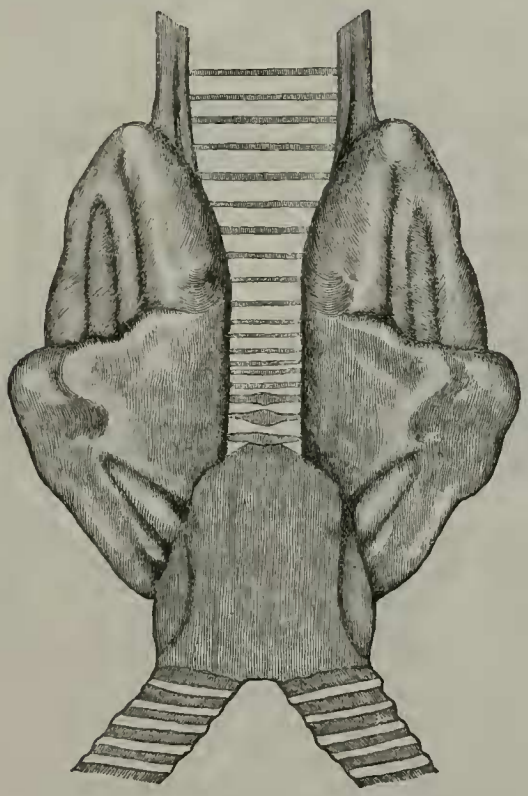
Tetrao urogallus and *T. tetrix* conform to a type which has several important differences from *Lagopus scoticus*, although in common they have the yielding cartilaginous (and never ossified) rings throughout the organ under consideration, as well as the great development in length of the bronchial semirings beyond the second.

In the female of *Tetrao tetrix* the first feature that strikes the observer is the consolidation of all the intrathoracic tracheal rings along the mid-posterior surface into a vertical bar, rendered more than it would be otherwise conspicuous by the considerable thinning of the lateral third or more of each ring on each side, and the consequent formation of lateral interannular spaces slightly deeper than the rings enclosing them. In the adult bird no trace of the transverse lines of junction between the constituent transverse annular elements of this vertical posterior bar can be seen; in the young bird, however, they are conspicuous. Anteriorly the rings above the antepenultimate are separated by an interval which slightly reduces the lowest of them, and that only, towards the middle line. There is a median semifusion in front, of considerable breadth, between the antepenultimate and penultimate rings, below which a broad cordiform cartilage represents the fused mid-anterior elements of the penultimate and last rings, with which the anterior extremity of the first bronchial ring is blended, and the second articulates, in such a way as to form lateral extensions of its apex. The line constituting the actual angle between the contiguous sides of the bronchi —produced, as just indicated, by the apex of the cordiform cartilage, together with the inferior margins of the lateral expansions, composed of the anterior ends of the first and second bronchial semirings —is less concave downwards than in *Lagopus* (in fact almost straight), and much less so than in the other Gallinæ. It has, in *Tetrao*, a very slight descending protrusion in the actual centre—the apex of the cordiform cartilage. Posteriorly each free end of the last tracheal ring expands and sends downwards and outwards a small process for the articulation and fusion with the similarly enlarged extremity of the first bronchial semiring. Upwards it blends with the base of the vertical posterior cartilage, which is considerably broader opposite the lowermost three tracheal rings than higher up. Into the middle of its base the narrow pessulus is seen to run. There is a great similarity between the depth and shape of all the interannular intervals in the bifurcating portion of the tube, the compara-

tively great depth of the intervals between the lateral parts of the last tracheal and the first bronchial semiring, observed in *Thaumalea* for instance, not being seen. The first and second bronchial semirings themselves, agreeing as they do with those of *Lagopus* in all respects, are of the same thickness as their neighbours both above and below—the result being simplicity of construction a little more apparent than real. Many of the bronchial semirings are bifid at their anterior extremities.

In the male of *Tetrao tetrix* the trachea is most extraordinary. At first sight the deeply situated intrathoracic part appears to have

Fig. 19.



Front view.
Tetrao tetrix, ♂.

no similarity with that of the female, there being developed, on each side, an immense irregular tumefaction, communicating with its fellow by means of a bridge of fatty tissue which covers the anterior portions of the lowermost tracheal rings. When preserved in spirit this tumefaction shrinks to a comparatively small size, to swell to its original bulk upon immersion in water. This leads me to suppose that it is composed of "mucous" tissue, like that of the umbilical

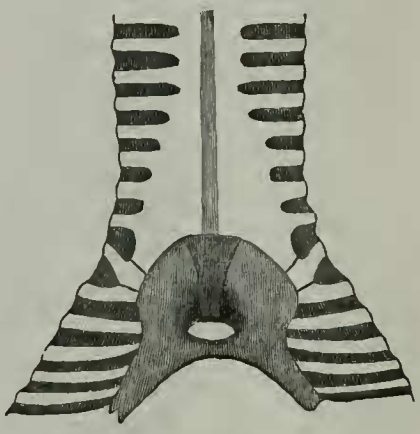
cord, which it resembles in consistence. The "mucous" tissue in this case is entirely developed between the external fibrous covering of the windpipe and the middle ring-carrying layer, the rings themselves not varying in the least, as far as I can detect, from their arrangement in the female.

Tetrao urogallus (a male, not quite full-sized, and without any trace of the cervical loop developed) differs from the female of *T. tetrix* only in a few details. All the rings and semirings are thinner, and the interannular intervals greater. The posterior vertical bar is undistinguishable. Anteriorly, however, the lowermost seven tracheal rings are not thinned in the middle line, where they, above the penultimate, articulate above and below to form what becomes almost an anterior vertical bar as well. The corresponding parts of the

Fig. 20.

Front view.

Fig. 21.



Back view.

Tetrao urogallus.

penultimate and last rings, considerably narrower than in *T. tetrix*, expand and consolidate into an elongate lozenge, with a much shorter one above it, from the lateral angles of which the rings are continued, and from the inferior angle of the lower of which the articulating (and subsequently fusing) surfaces for the anterior ends of the first bronchial rings arise. The second semiring also articulates with the first, as in the allied birds, with, however, a considerably larger interannular interval than in *T. tetrix*. The lateral parts of the first semiring being markedly convex upwards, at the same time that the incurved last tracheal ring sends downwards rather lengthy processes from its posterior extremities as well as the deep lozenge-shaped cartilage in front, the interval between the two agrees with the section of a plano-concave lens. Some of the bronchial semirings are bifid at their extremities; and the bronchidesmus is very strong.

Tetrao cupido is intermediate in its tracheal bifurcation between *Lagopus scoticus* together with *L. mutus*, on the one hand, and *Tetrao*

urogallus with *T. tetrix* on the other. Its cartilages are considerably less yielding than those of either genus; and the lower tracheal rings, instead of fusing behind to form a continuous longitudinal bar supporting the remaining parts of the rings upon each side, remain separate, in close contact, for the posterior half of their circumference. The pessulus interpolates its considerable cuneate posterior end as high as the antepenultimate ring, which it splits up. The lowermost nineteen tracheal rings are considerably thinned in front, the uppermost being least so. Of these, the antepenultimate ring, as well as the one above it, give indications of being bent downwards in the middle line in front. This angulation is more marked in the penultimate ring, and most so in the last ring, where a mid-anterior rhombic cartilage exists, of exactly the same shape as in *Lagopus scoticus*. The first and second bronchial semirings agree precisely with those of the last-named species, convexly *upwards* as they are curved; and, as in all the species of *Lagopus* and *Tetrao*, the bronchidesmus is strong, at the same time that the bronchial semirings almost completely encircle the tubes, leaving a very narrow membranous unsupported wall. The bronchial tubes are comparatively lengthy.

Fig. 22.

Front view.

Fig. 23.

Back view.

Perdix cinerea.

In *Perdix cinerea* the intrathoracic portion of the trachea is quite different from the same in *Caccabis* or any of the birds above described. The last and penultimate tracheal rings are much developed, and blend to form the considerable three-way piece, which is triangular in front, apex downwards, and horizontally oblong behind. Of the anterior triangle, which is ossified, the two sides are formed by the last ring, whilst the penultimate ring constitutes the base, the intervening interval being filled up with a thin cartilage. The apex of the triangle is continued downwards in cartilage, this latter being deeply notched in the middle line, at the same time that the anterior extremities of the first and second slender and upward-arched bron-

chial semirings blend with it laterally. Laterally, the separation between the last and penultimate rings is feebly indicated, as it is posteriorly by the non-ossification of the latter, notwithstanding the blending of the two. Posteriorly the oblong ossified cartilage, with its unossified and slightly indented upper margin (the part formed by the penultimate ring), is joined by the slender pessulus in the middle of its lower edge, whilst it is with its lower extreme angles that the simple posterior extremities of the first bronchial half-rings blend, the same parts of the second semirings not participating in the fusion, and being almost if not quite free, as are those below it at both ends. All the upper bronchial semirings are slender, strongly convex upwards, and separated by intervals not greater than their depth. The interval between the last tracheal ring and the first semiring, to which it is united both in front and behind, is fairly deep and crescentic. The antepenultimate ring is very much slenderer than the one below it, from which it is separated by a large interannular interval, deeper in front than behind on account of the obliquity of its plane. Anteriorly it is very shallow and insignificant; and it gradually enlarges as it goes backwards. The ring above it is scarcely different, but slightly less oblique, the interannular interval between it and the fifth from the end being slightly less than that next lower down. This fifth ring first gives indications of a latero-posterior deepening, with a corresponding reduction of the interannular interval and the formation of an antero-median horizontal fusiform space, the only remains of the interannular interval recognizable higher up, and extending into the cervical portion of the windpipe.

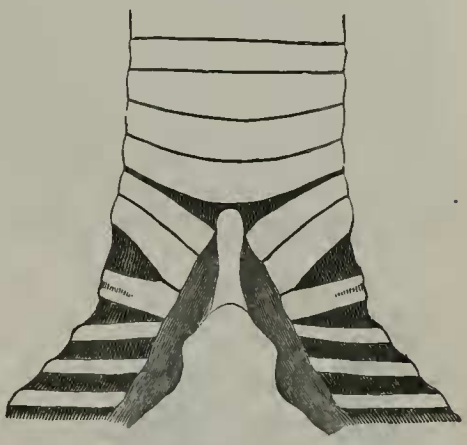
Ceriornis temmincki differs from all other Gallinæ examined by me, except *Francolinus vulgaris*, in that the *third* bronchial semiring articulates with the second, and so participates in the formation of the specialized organ under consideration. None of the tracheal rings are narrowed; and there are consequently no interannular intervals of any kind, if we except the one on each side of a narrow anterior isthmus which runs between the penultimate and the last ring. This interval is guttate in shape, on account of the slight upturning of the lateral element of the last ring, the antero-median part of which is expanded, almost exactly as in *Euplocamus*, into a quadrate cartilage. The pessulus at its posterior extremity is unattached, though situated as usual. Its freedom depends upon the fact that the penultimate as well as the last tracheal ring is incomplete behind, the end of the pessulus filling the deficiency and just touching the lower margin of the complete antepenultimate ring. This may possibly be the normal arrangement, all others resulting from subsequent consolidation. The first and second bronchial semirings are very much alike. The relations of the upper of them to the ring above, as well as those of the lower to the ring below, are almost identically those of *Euplocamus*; whilst posteriorly they consolidate together for one half their length, a small elongate fusiform interval existing external to their anterior fused extremities. With the lower of them the slightly-bowed third semiring articulates

at one end, and the other (as does the second in *Euplocamus*) with the first. *Ceriornis satyra* agrees exactly with *C. temmincki* in its lower larynx.

Fig. 24.

Front view.

Fig. 25.



Back view.

Ceriornis temmincki.

My acquaintance with the trachea of *Francolinus* is confined to *F. vulgaris*, an early sketch, too, only of that. Its great peculiarity is that the first *three* bronchial semirings articulate together, the third being decidedly the strongest, the first and second being separated by a greater interval than exists in *Ceriornis*.

In *Crossoptilon mantchuricum* the thoracic end of the trachea is euplocamine in construction. It narrows considerably near its termination, at which it again expands. The only indications of interannular intervals are small medio-anterior fusiform spaces, absent between the antepenultimate and penultimate rings, and replaced by a fusion in the case of the last two, on each side of which the lateral separation between the rings expands into a minute triangular interval, smaller than in *Euplocamus*. The pessulus agrees with that of the *Euplocami*. The interval between the last tracheal ring and the first bronchial semiring is very large, both upper and lower margin being about equally convex upwards, from the shape of the last tracheal ring and the uptilting of the first semiring. The interval between the first and second semirings is scarcely smaller, and is ovoid, the latter semiring being decidedly downturned laterally, bent upwards abruptly near its ends, and particularly strong throughout. On the whole, the organ is more like that of *Phasianus* than *Euplocamus*, its most striking difference from the former being the lateral uptilting of the first bronchial semiring, and the similar tendency in the sides of the last tracheal ring.

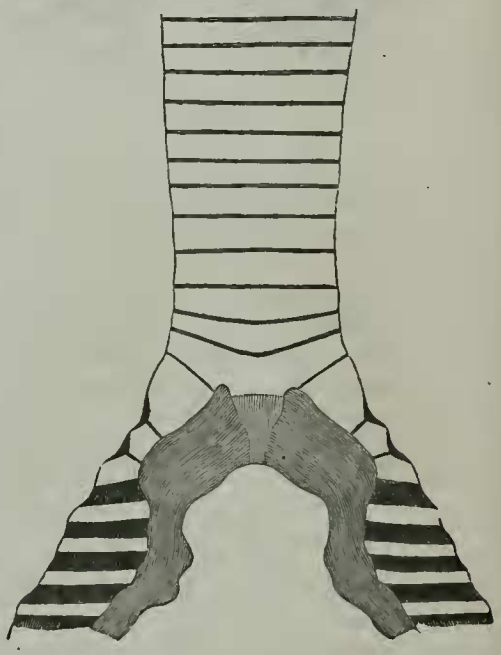
In *Lophophorus impeyanus* the lower tracheal rings, which are narrower than those above, are in contact with one another behind;

but anteriorly they are thinner, leaving considerable intervals, diminishing as they ascend—continuous between the five rings above the penultimate, found also between it and the last, but in that case interrupted by a small median connecting isthmus, which is broader below than above, at the same time that it is continuous with the superiorly broader medio-anterior descending process of the last ring, the two together forming a lozenge-shaped cartilage that receives the extremities of the first semirings at its lower margin. Posteriorly the pessulus is continuous with the penultimate ring, whilst the ends of the last tracheal also blend with it slightly. The second bronchial semiring is slightly larger than the first, and articulates with it in the usual way, as does the first with the last tracheal ring. There is a great uniformity in the depths of all the interannular intervals in the region of the bifurcation of the trachea.

Fig. 26.

Front view.

Fig. 27.



Back view.

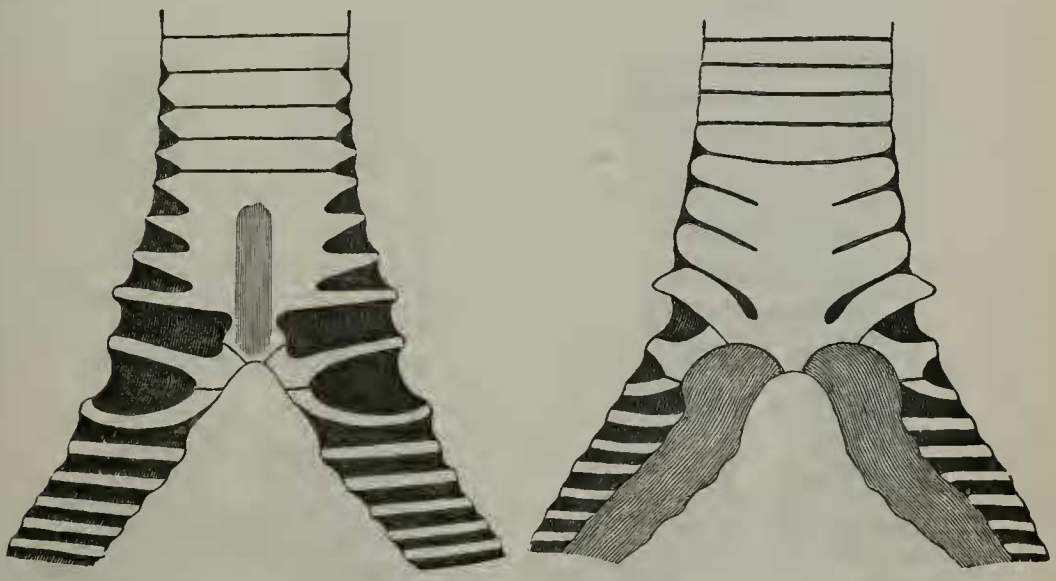
Crossoptilon mantchuricum.

In *Numida cristata*, which may be taken as the type of the very characteristic windpipe of the genus, figured accurately as it is in part by Temminck [1], the peculiarity is that the lowermost six or so tracheal rings develop antero-lateral fenestræ between them, increasing in size from above downwards, and produced by the thinning

[1] *Loc. cit.* pl. i. fig. 4.

of the rings alone. In the adult male the four lowest rings blend in the middle line, both anteriorly and posteriorly. Those higher up do not do so. The last ring of the trachea, the whole plane of which is transverse, sends downwards a bluntly triangular medio-anterior process, with the lower margin of which the first bronchial semirings articulate. Posteriorly, in the full-grown bird, the pessulus fuses with the hinder extremities of the same, in such a way as to make it appear to form a continuation of it, as in no other of the Gallinæ with which I am acquainted. The first bronchial semiring sends upwards at right angles a strong anterior articular process, it posteriorly expanding triangularly, so that the upper angle meets the lower margin of the last tracheal ring in the usual

Fig. 28. Fig. 29.



Front view. Back view.

Numida cristata.

situation, the lower angle articulating with the second semiring, whose other end bends up to be jointed to the corresponding part of the first semiring, developed slightly downwards to articulate with it. The interval between the last tracheal ring and the first bronchial semiring is considerable and broadly quadrilateral ; that below it is much shallower ; and those above are fusiform, diminishing gradually as they ascend, until the last is quite minute.

N. ptilorhyncha and *N. rendalli* are very similar. They agree with one another, and differ from *N. cristata* in that the extreme lateral edges of the penultimate and last tracheal rings meet and blend, thereby reducing the interannular interval to a guttate form,

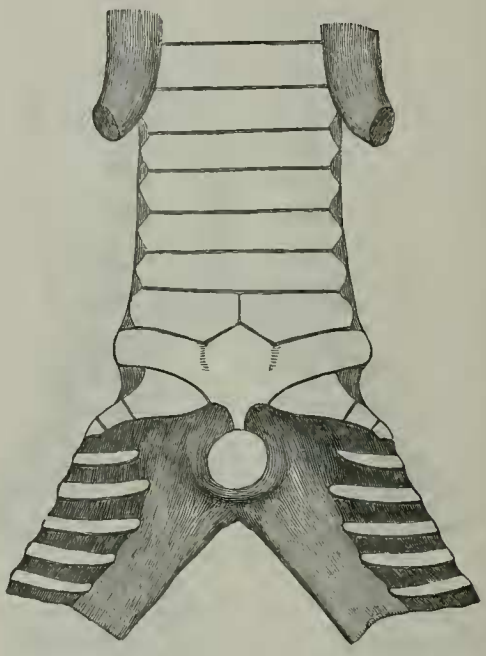
with the apex directed outwards. In *N. vulturina* there are as many as ten pairs of lateral tracheal fenestræ.

In *Meleagris gallopavo* the intrathoracic rings are all thinned away in front, whilst posteriorly they are not so, the consequence being that considerable interannular intervals separate them anteriorly, entirely absent posteriorly. The antepenultimate and penultimate rings are alone joined by a median anterior isthmus of cartilage. The former of these is split across behind; the latter is not so, the fairly thick pessulus blending with the mid-posterior margin, its apex apparently producing a protrusion of its upper border between the sides of the fissure in the ring above. The penultimate ring is greater in diameter, and stronger than the rest. *The last tracheal ring is represented only by the posterior extremities of the*

Fig. 30.

Front view.

Fig. 31.



Back view.

Meleagris gallopavo.

normal ring, its lateral and anterior parts having quite disappeared, in the half-grown, and perhaps even younger bird. It will be remembered that its lateral elements are much reduced in *Lagopus*. In *Meleagris* the reduction has gone further, the only remainder being the inverted blunt triangular cartilage that intervenes between the juxta-pessular margin of the penultimate ring and the posterior articulation of the first bronchial semiring on each side of the organ. A minute pointed process of the outer margin of the cartilage under consideration indicates the situation of the posterior root of the

lateral portion of the atrophied ring. The first and second bronchial semirings are upturned laterally, and more slender than those below them. The first anteriorly sends upwards and inwards a lengthy process of about three times the thickness of the body of the ring itself, cut away obliquely, so that its upper end looks inwards and a little upwards, nearly to meet its fellow, from which it is separated by a narrow triangular fibro-cartilage, developed at its base from the middle of the antero-inferior margin of the penultimate ring of the trachea. The second semiring is slightly swollen at its ends to articulate with the semiring above. The interval between the penultimate ring and the first semiring is necessarily considerable, and is quadrate as well as slightly biconcave; that between the first and second semiring is meniscoid, convex upwards, and shallow. The bronchial semirings below the second are peculiarly lengthy, especially the fifth, and pointed at the ends. Strangely, also semiring three, a short distance external to its anterior termination, articulates by small special facets with those above and below. The bronchidesmus is particularly strong.

By Temminck[1] this windpipe is imperfectly figured.

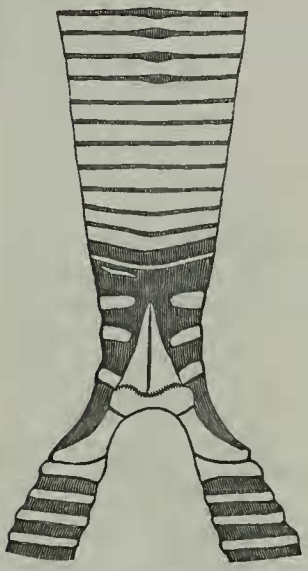
Gallus bankiva at first sight seems to have the lower end of its windpipe constructed upon quite a different type from that of any of its allies, although I have reason to believe that other species fill up the gaps between it and other Phasianidæ. The lower extremity of the trachea is very much compressed from side to side, whilst it is correspondingly augmented in depth from before backwards. The antero-posteriorly directed pessulus joins in front the base of a considerable median triangular cartilage, which, with upward-directed small-angled apex, reaches as high as the level of the antepenultimate tracheal ring; posteriorly it joins a similar but smaller cartilage, the apex of which does not quite reach the penultimate ring. With the lateral angles of these triangular cartilages, the anterior and posterior extremities of the first bronchial semirings freely articulate. These semirings are large and much curved, with the convexity directed downwards. Anteriorly they meet, but do not articulate with the scarcely modified second semirings, from which they are quite independent behind.

The last tracheal ring is thin and band-like, joining the lower ends of the sides of the anterior triangular cartilage in front, whilst behind its free extremities are separated by a considerable interval, partly occupied by the posterior triangle. The penultimate ring persists as two straight lateral band-like rudiments fixed in the tracheal membrane, and *nearly* reaching both the anterior and posterior triangular cartilages. The antepenultimate ring is still further modified in the same direction, only the antero-lateral parts persisting as rudiments, not seen, therefore, in the back view of the organ. A short distance above the level of the apex of the anterior triangular cartilage, and some way below the first fairly normal tracheal ring, is a continuous filamentous transverse cartilage, with little extra pieces connected to it—incomplete in the middle line

[1] *Loc. cit.* pl. iii. fig. 8.

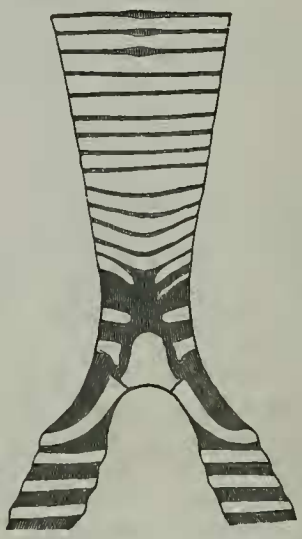
behind, supported by the membranous walls of the windpipe. This is evidently the atrophied fourth ring, counting from below. Above this an abrupt change occurs; the rings attain their ordinary depth, with only linear intervals between them. The fifth ring, again counting upwards, differs from those above it in being slightly incomplete behind, with downturned ends. The interval between it and the fourth is about equal to its own depth. It in front, and its

Fig. 32.



Front view.

Fig. 33.



Back view.

Gallus bankiva.

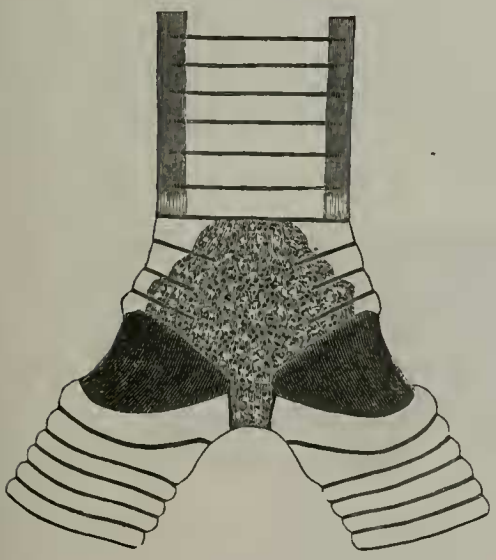
superior two or three neighbours behind as well, is slightly V-shaped in the middle line[1].

The Cracidæ are particularly uniform in the manner in which the trachea bifurcates. In *Mitua tuberosa* there are no tracheal interannular intervals of any kind. The pessulus is united with the penultimate ring posteriorly and with the last ring in front, the latter ring being therefore incomplete behind, as in all the birds above described. Mid-anterior and posterior ossifications extend upwards from the attachments of the pessulus, generally sufficiently high to involve the four lowermost rings, which are therefore consolidated together in the median lines. The lower lateral borders of the last tracheal ring are slightly concave downwards; the medio-anterior descending process being small, whilst by its slightly truncated triangular apex it forms a small portion of the actual margin of the bifurcation. On account of the considerable length of the

[1] By Temminck (*loc. cit.* pl. ii. fig. 4) a different figure of the windpipe of *G. bankiva* is given.

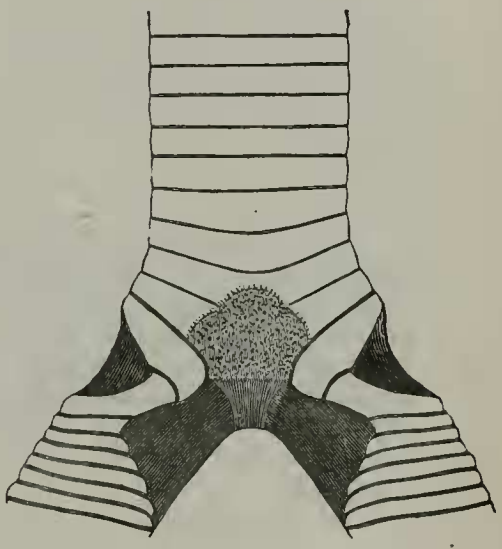
slender first bronchial semiring, which is very concave upwards, the interval between it and the last tracheal ring is conspicuously large and fusiform, one side of the small antero-median process and the *outer* border of the inferior angle of the corresponding truncated posterior termination of the last tracheal ring being its articulating spots. The semiring is not of uniform thickness, small expansions, not unlike the "tubercles" of ribs, occurring at a short distance from both ends, which mark the points at which the next semiring meets it and ceases. The second semiring is simple, except that it is slightly enlarged at its posterior extremity. The interval between it and its neighbours is extremely narrow.

Fig. 34.



Front view.

Fig. 35.



Back view.

Aburria carunculata.

The species I have examined are *Crax globicera, C. carunculata, Pauxis galeata, Mitua tomentosa, Penelope jacucaca, P. cristata, P. superciliaris, Pipile cumanensis,* and *Aburria carunculata.* In *Penelope, Pipile,* and *Aburria* the first bronchial semirings are thicker and stronger than in *Crax* and its near allies, their posterior articulations with the ends of the last tracheal ring being upon what becomes the *outer,* but normally would be the *inferior* surfaces of its juxtapessular terminations, because of a characteristic downward flexure of their expanded obtuse extremities.

The lateral intrinsic tracheal muscles are thin, and run down to cease opposite the ring fifth from the bifurcation of the tube, as in nearly all Gallinaceous birds. I cannot trace any fibrous continuation to the lower rings from their muscular extremities.

Incidentally it may be mentioned, with reference to the development of the extrathoracic tracheal loop in the Cracidæ, that, as far

as my facts go, this loop is found in the males only of the genera *Crax*, *Pauxis*, and *Mitua*; whilst in *Penelope purpurascens*, *P. cristata*, *Pipile*, and *Aburria* it is wanting in both sexes, it being present in both sexes of *Penelope jacucaca*. In the males of *Penelope pileata* and *Ortalida albiventris*[1] it is present; the females I have not seen.

The flattening of the trachea of the male Cracinæ, excellently depicted (inverted) in Temminck's figure of the windpipe of *Crax alector*[2], is lateral or from side to side, so that the well-known anterior and posterior notching of the rings of the trachea is on the thin edges of the flattened tube.

In conclusion, it may be asked what light this detail concerning the bifurcation of the trachea throws on the mutual affinities of the genera of the Gallinæ. It is very infrequently that the study of a single organ justifies the formation of an ultimate classification of any group; and the windpipe of the Gallinæ is not peculiar in this respect. Several hints are to be derived from this investigation, however, not unimportant in my estimation.

Pavo seems to stand alone on account of the simplicity of its bronchial bifurcation.

There seems also to be a tendency for the majority of the Gallinæ to fall into two divisions, a Coturnicine and a Phasianine; in the former of which it is the bronchial semirings which are most specialized, at the same time that their anterior extremities are pointed and produced inwards. In the latter group it is the last tracheal ring that is most modified, its sides being always upturned. Upon this assumption it is not easy to place the genera *Gallus*, *Lophophorus*, *Meleagris*, and *Numida*. The others fall into the following order:—

Coturnicinæ.	Phasianinæ.
Caccabis.	*Euplocamus.*
Argus.	*Pucrasia.*
Polyplectron.	*Ceriornis.*
Ithaginis.	*Phasianus.*
Lophortyx.	*Thaumalea.*
Oreortyx.	*Crossoptilon.*
Arboricola.	*Lagopus.*
Rollulus.	*Tetrao.*
Ptilopachys.	(*Meleagris*?).
Coturnix.	*Perdix.*

It is surprising to see how much the lower end of the trachea of the adult *Gallus* differs from that of *Phasianus* and its allies. A study of the development of the windpipe of the Common Fowl—which I have not had the opportunity of undertaking—would probably throw considerable light upon the subject.

[1] *Vide* Temminck, *loc. cit.* pl. viii. fig. 1.

[2] *Loc. cit.* pl. v. fig. 1.